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EVALUATING MINIMUM APTITUDE STANDARDS

Milton H. Maier
Paul W. Mayberry

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ABSTRACT

The evaluation of aptitude standards to determine qualification into military specialties must address issues concerning both the minimum qualifying score and the appropriate aptitude distribution above that minimum. This research memorandum is an initial effort that focuses on identifying the minimum qualifying aptitude score for assigning recruits to occupational specialties. Hands-on job performance tests developed for the Marine Corps infantry occupational field provide the context for the analysis. Subsequent research will address the evaluation of the necessary aptitude distributions.

EXECUTIVE SUMMARY

This research memorandum is an initial effort to evaluate aptitude standards for the selection and assignment of Marine Corps recruits to various occupational specialties based on the Armed Services Vocational Aptitude Battery (ASVAB). The study focuses on identifying the minimum qualifying aptitude score for assigning recruits to the infantry occupational field. Subsequent research will address the issue of the aptitude distribution needed to achieve the Marine Corps' performance requirements.

Minimum qualifying aptitude scores are derived in two stages. The first stage is to evaluate the minimum level of performance that is satisfactory to the Marine Corps. Next, based on the relationship between aptitude and performance, the qualifying aptitude score associated with the minimum performance requirement is calculated.

METHODOLOGY

The evaluation of aptitude standards must reflect Marine Corps policy and procedures. However, such policies must be defined in quantitative terms for use in analyses. The policy statements are used to compute the minimum performance requirement and then are applied to results from the Marine Corps Job Performance Measurement (JPM) project to determine a corresponding minimum aptitude score.

Defining the Performance Requirement

The Marine Corps' policy concerning unsatisfactory performance has generally been applied to formal training courses such that academic failure rates would not exceed 10 percent. Undue academic problems, recycles, and eventual reduced job performance are typically the result if this failure rate is exceeded. The 10-percent rule has served as the historical average for managing performance resulting from training as well as limiting the number of undesirable outcomes. The rule was applied to the more objective performance criterion of hands-on job performance collected for the infantry.

The 10-percent rule for determining the performance requirement is specified in terms of a failure rate, not an absolute point on the performance scale of the JPM tests. Therefore, it is necessary to specify a target population that is relatively stable and reflects the population of potential inductees so that consistent and accurate decisions can be made across a variety of economic conditions and recruiting environments. The target population was obtained from the 1980 youth population study, a nationally representative sample of 18- to 23-year-old males and females who were administered the ASVAB. The population used here was restricted to males (since the focus is on

combat specialties) and excluded persons of extremely low aptitude who are legally ineligible for service (called category V personnel).

Because job performance typically increases as persons gain experience and receive on-the-job training, the length of job experience must also be specified when defining the performance requirement for evaluating qualification standards. A reasonable point at which to evaluate satisfactory performance is when people have matured and are eligible for promotion to leadership positions (pay grades E4 and greater). In the Marine Corps, this is typically at two years of service.

The performance requirement was computed by applying the 10-percent failure rule to the distribution of predicted job performance for the male inductee population at the time when persons are considered for promotion to leadership positions (24 months time in service (TIS)). This process required:

- Defining the male inductee population as the 1980 youth population minus category V personnel
- Predicting the performance distribution for this population at 24 months TIS based on the regression determined from the infantry JPM sample
- Finding the point in the predicted performance distribution that identified the bottom 10 percent of the population; this value defines the minimum performance requirement.

Computing the Minimum Aptitude Standard

The minimum aptitude standard is determined based on the regression of hands-on performance on aptitude and TIS. The regression is solved for the aptitude score that would result in the minimum performance requirement at the time when persons may be required to enter combat (four months TIS). The objective is to access personnel with sufficient aptitude to perform satisfactorily at the end of 16 weeks--the earliest time that a Marine could be sent into combat during the Vietnam conflict.

RESULTS

Based on the infantry results, a predicted performance distribution was generated for the 1980 male youth population (less the legally ineligible persons) at 24 months of service. The performance score of 179 identified the 10th percentile of the distribution, so this value defined the minimum performance requirement based on the application of the 10-percent rule.

The regression of hands-on performance on aptitude and TIS resulting from the infantry data was

$$P = 124 + .66 GT + .51 TIS ,$$

where P is predicted hands-on performance, GT is the General Technical (GT) aptitude composite, and TIS is time in service (months). The GT score that predicted the minimum performance requirement (179 at four months TIS) was 80. This minimum aptitude score implies that a cohort selected based on this standard will have satisfactory levels of predicted performance at the time that individuals may be required to enter combat (given that the cohort has similar aptitude characteristics to the 1980 male youth population minus category V personnel).

Some of the potential tradeoffs between the outcomes of various minimum aptitude standards are discussed to highlight the problems confronting policy makers in establishing minimum standards and to serve as an introduction to the issues that must be addressed for the next stage of evaluating standards--determination of the necessary aptitude distribution.

CONCLUSIONS

The current qualifying GT score for assigning recruits to Marine infantry specialties is 80. The method used in this study for determining the minimum aptitude standard is consistent with previous Marine Corps standard-setting procedures in that objective hands-on performance data were substituted for the training criterion that has historically been used. The close agreement between the current standard and the results of these analyses support the present standard-setting practices, which are based on years of experience, dating back to the Vietnam era. Even though manpower managers typically do not have objective hands-on tests to assess performance or a clearly defined population of recruits, their ability to estimate minimum performance requirements is supported by these analyses.

Identifying the performance requirement is the most difficult aspect in evaluating enlistment standards. It is also a dominant factor in determining the minimum aptitude score. Specification of the performance requirements must be directly related to the absolute demands of the job. The application of the 10-percent rule has deferred this specification of the absolute job requirements by the Marine Corps. The assumption is that the 10-percent rule is an accurate assessment of the Marine Corps' absolute performance requirements for the infantry occupational field. To the extent that the 10-percent rule is a reasonable estimate of the absolute performance requirements, the minimum aptitude standard of 80 should ensure that significant numbers of unsuccessful performers are not accessed.

The 10-percent rule has been applied with some flexibility in the past, but the general perception has been that higher failure rates result in the unfavorable outcomes of recycles and degraded levels of job performance. The estimate of the performance requirement resulting from the 10-percent rule can be no better or more stable than the policies that regulate and guide the accession process. The use of the 10-percent rule was one attempt to quantify the performance requirement. Other efforts should be conducted to confirm these outcomes.

In a simple way, the tradeoffs and comparisons among the outcomes of various minimum aptitude standards exemplify the thought process conducted by policy makers. As with all policy-related issues, extensive value judgments are involved. This paper is a first attempt to make these value judgments explicit, by translating decisions into an empirical framework for determining minimum aptitude standards. The tradeoffs have not incorporated explicit costing information. This calculation of a minimum aptitude standard has not been an optimal determination in the sense of balancing the benefits of higher standards (better job performance, fewer failures) against the costs of such standards (higher recruiting costs and enlistment incentives). However, such tradeoff issues were discussed to highlight the problems confronting policy makers and to serve as an introduction to the issues that must be confronted for the next stage in evaluating enlistment standards--determination of the aptitude distribution above the minimum score.

Significant improvement in selection decisions is the primary goal for using aptitude tests in the accession process. However, because the selection test is not perfectly related to performance, some incorrect selection decisions are inevitable. These incorrect decisions impact both the services (who will access a limited number of unsuccessful performers) and applicants (who would have been successful performers if selected). The goal of setting aptitude standards is to find an equitable balance that allows the services to accomplish their missions while protecting applicants who seek the advantages that the services have to offer.

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INTRODUCTION

The Marine Corps Job Performance Measurement (JPM) project was initiated in 1981 to evaluate aptitude standards for qualification into occupational specialties against objective measures of job performance. The historical criterion of training grades was questioned during the 1976-1980 period because of problems with the Armed Services Vocational Aptitude Battery (ASVAB), the instrument used for selecting military recruits. At that time, significant numbers of unqualified personnel entered the services because ASVAB scores overestimated individuals' aptitude levels. The impact on military effectiveness of such low aptitude and unqualified personnel could not be empirically established. The JPM project was charged with accurately measuring the job performance of military personnel and directly relating this performance to the evaluation of qualification standards.

The evaluation of qualification standards is based on two steps: (1) the identification of a minimum aptitude standard, below which persons are not eligible for service and (2) the determination of the aptitude distribution above that minimum standard so that the quality of personnel accessed will be sufficient to accomplish the service's job requirements. The minimum aptitude standard is a necessary, but not sufficient, condition in the evaluation of qualification standards. This standard merely serves as a floor below which a person's predicted performance is considered unsatisfactory. Not all persons selected can have minimum aptitude scores. The qualification standard also requires a distribution of aptitude above this minimum score to ensure that the service will have qualified personnel capable of performing to the required level.

Both aspects of qualification standards--minimum qualifying score and adequate aptitude distribution--are always present in the accession process. However, under different conditions, they receive different emphases from manpower managers. The primary function of standards during times of mobilization is to keep out of the services (and out of particular occupational specialties) those persons who have a high likelihood of failure. Conscription results in a wide distribution of aptitude scores because almost all persons are potential inductees; qualification standards must therefore focus on minimum aptitude scores. Conversely, during all-volunteer conditions, the manpower procurement process does not ensure such a wide distribution of aptitude scores--the required number of persons with high aptitude scores must be actively recruited and assigned to appropriate specialties. When all accessions need to be recruited, the primary function of qualification standards is to ensure that the required distribution of aptitude scores is obtained.

It follows that the proper evaluation of qualification standards must address both the minimum qualifying score and the appropriate aptitude distribution. This research memorandum focuses on identifying the minimum qualifying aptitude score for assigning recruits to

occupational specialties. Hands-on job performance tests developed for the Marine Corps infantry occupational field provide the context for the analysis. In subsequent research, procedures and results for evaluating adequate distributions of aptitude scores, particularly with respect to cost-performance tradeoffs, will be addressed.

The evaluation of qualification standards must reflect Marine Corps policy and procedures. Qualification standards have historically been set with some degree of subjectivity, because an objective base for evaluating performance has not been routinely available. In the Job Performance Measurement (JPM) project, however, objective measures of job performance are available. By incorporating longstanding policy decisions, the objective measures of performance can be used to evaluate reasonable qualifying standards.

Minimum qualifying aptitude scores are derived in two stages. The first stage is to evaluate the minimum levels of performance that are satisfactory. The second stage is to determine the qualifying aptitude scores associated with minimum levels of satisfactory performance.

The purpose of this paper is to present a rationale for evaluating minimum qualifying standards that incorporates policy guidance and directives together with data from the Job Performance Measurement (JPM) project. First, policy guidance and directives will be discussed and defined more precisely for use in quantitative analyses. The policy statements will then be applied to results from the JPM project to compute minimum qualifying aptitude scores.

POLICY GUIDANCE AND DIRECTIVES

Three policy statements will be used to evaluate qualifying aptitude scores:

- The Marine Corps, and other services, have a "rule of thumb" that the rate of unsatisfactory performance should not exceed 10 percent of the population.
- By law, people with aptitude scores below the 10th percentile are not eligible for service. Combat specialties are also limited to males.
- By law, people with less than 16 weeks of time in service (TIS) cannot be sent overseas, and, hence, into combat.

Policy Defining Unsatisfactory Performance

Identifying the performance requirement is the most difficult aspect in evaluating enlistment standards--what level of performance is satisfactory? The validity results of the JPM project simply imply that more is better--more aptitude results in more performance. The results do not specify how much performance is needed.

The policy guidance of the services defining unsatisfactory performance has not referred to objective performance measures for specified job requirements. For most enlisted specialties, objective measures of job performance have not been available. The services typically have used performance in training courses as a surrogate for actual performance on the job.

The services' policy concerning unsatisfactory performance has generally been applied to formal training courses such that academic failure rates do not exceed 10 percent. Although there has been some flexibility in the application of this rule of thumb, the services have noted that undue academic problems, recycles, and eventual reduced job performance were the result if this failure rate was exceeded. Therefore, if the failure rate in a course exceeded 10 percent for academic reasons, the qualification standard for that specialty required management attention. The 10-percent rule has served as the historical benchmark for managing the desired levels of performance resulting from training as well as for limiting the number of undesirable outcomes.

For this research memorandum, the 10-percent rule is applied to the objective performance measures developed in the JPM project [1]. The object is to determine the lowest performance level that has historically been acceptable to the service and that is consistent with their past management of the standards process.

Specification of the performance requirements must directly reflect the absolute demands of the job. Such requirements are independent of the JPM project, except to the extent that test content was selected to be representative of the job requirements. Thus, while the linkage between aptitude and job performance is established through hands-on performance testing, there is no explicit linkage between the 10-percent rule of thumb and the Marine Corps definition of the performance requirements for the infantry occupational field. Nothing is sacred about 10 percent other than the historical trends noted in the training arena.

The application of the 10-percent rule has deferred the specification of the absolute job requirements by the Marine Corps. The assumption is that the 10-percent rule is an accurate assessment of the Marine Corps' absolute performance requirements. Two additional assumptions are also made for these analyses, but these will have an impact on any methods used to establish the Marine Corps performance requirements:

- The effectiveness of training in producing satisfactory levels of job performance will remain the same. If either the frequency, recency, or effectiveness of training is significantly altered (either for the better or for the worse), then aptitude standards would need to be adjusted to compensate for the associated change in performance.

- Job requirements will not significantly change from the tasks that were tested as part of the JPM project. Technological advances or improved weapon systems would impose different job requirements on personnel and therefore necessitate a re-examination of the aptitude standards so that performance requirements can be satisfied.

Policy Specifying Target Population

The 10-percent rule for determining the performance requirement is specified in terms of a failure rate, not an absolute point on the performance scale of the JPM hands-on tests. Since the 10-percent rule is relative determination dependent on the group to which it is applied, it is necessary to specify a target population that is relatively stable and reflects the population of potential recruits. In this manner, the rule becomes absolute because it is always applied to the same population. Consistent and accurate decisions can then be made across a variety of economic conditions and recruiting environments during which the quality of individual cohorts is apt to vary.

This target population to which the 10-percent rule should be applied is that of the potential inductees during times of mobilization. This population was obtained from the 1980 youth population study [2], which was a nationally representative sample of 18- to 23-year-old males and females who were administered the ASVAB. By law, only persons with aptitude scores at or above the 10th percentile are eligible for induction and only males are eligible for combat specialties. The Armed Forces Qualification Test (AFQT) is used as the aptitude measure to define the 10th percentile. The population of potential inductees then is operationally defined as the males of 1980 youth population with the bottom 9 percent of the AFQT scores deleted (this group is called category V personnel).

The specification of the 1980 male youth population minus category V personnel is somewhat a departure from the historical application of the 10-percent rule to the training community--a selected military population. This was done for two reasons. First, as alluded to earlier, the overall quality of a given cohort may vary across time or recruiting conditions. Adjustments in aptitude standards should not be made as a function of quality differences in personnel taking a particular course, but rather of the changes in the true demands of the job and the aptitude needed to master such requirements. The youth population serves as a stable reference against which the quality of available applicants can be anchored. Second, the central issue of a minimum aptitude standard is the processing of an applicant/inductee pool similar to the 1980 male youth population less category V personnel. Therefore, the ability to screen out those persons who will not be satisfactory performers based on a minimum qualifying score is of primary importance.

Policy Regarding Time of Performance Proficiency

In addition to defining the performance requirements and the target population to which those requirements are applied, the length of job experience must also be specified when evaluating qualification standards. As a rule, the quality of job performance increases as people gain experience and receive on-the-job training. A reasonable time to evaluate satisfactory performance is when people have matured and are normally eligible for promotion to leadership positions, which is paygrade E-4. In the Marine Corps, the minimum time (without meritorious promotions) to achieve this pay grade currently is 22 months of service. At this stage, people have had an opportunity to learn the basic skills and knowledge required for their jobs, and those who have demonstrated proficiency can be considered for promotion to first-line leadership positions. People who cannot learn the skills and knowledge likewise can be identified. Two years is a reasonable time to allow jobs skills and knowledge to mature.

As discussed earlier, the level of minimum satisfactory performance should be referenced to the population of potential inductees. The difficulty arises in trying to determine the performance score that defines the bottom 10 percent, which would then be labeled unsatisfactory according to the 10-percent rule. One procedure for determining this minimum performance score would be to accept a group that is representative of the population and give them the routine formal training and job experience. At the end of two years of service, their job performance would be evaluated, and the performance score that cuts off the bottom 10 percent of this group would be the minimum level of satisfactory performance.

Of course, no service would be willing to accept a group representative of the population. The risk and cost would be judged unacceptable. Instead, the minimum level of satisfactory performance can be estimated from the JPM project data. The outcome is presented in the results section.

Further, neither the Marine Corps, nor any other service, is willing to wait 24 months for people to become satisfactory performers. Given that the tour of duty for inductees in wartime traditionally is 24 months, people with marginally qualifying aptitude scores would tend to be unsatisfactory performers for almost their full tour of duty. Although infantrymen should be satisfactory performers when they are available for combat, during the Vietnam conflict, they could, by law, be sent overseas into combat after four months of training and experience. A reasonable constraint on qualifying standards is that persons must be of sufficient quality that their predicted performance at four months is consistent with the level of satisfactory performance established at 24 months.

METHODOLOGY

Data from the Marine Corps JPM project are used to evaluate a minimum qualifying aptitude score for the infantry occupational field. Each of the previous policy directives has been translated into a framework for empirical analysis. The following summary outlines these policy considerations and the analysis plan.

- Determine the performance requirement as the 10-percent failure rule applied to the predicted job performance of the inductee population at the time persons are considered for promotion to leadership positions (24 months TIS). This requires:
 - Defining the inductee population as the 1980 male youth population less category V personnel.
 - Predicting the job performance distribution for this population at 24 months TIS based on the regression determined from the infantry JPM sample (having corrected for range restriction).
 - Finding the point in the predicted job performance distribution that identifies the bottom 10 percent of the population; this value defines the minimum level of satisfactory performance.
- Based on the regression of hands-on performance on aptitude and TIS, solve for the aptitude score that will result in the minimum performance requirement at the time when persons may be required to enter combat (4 months TIS).

The next section describes the results of these analyses, followed by a discussion of the tradeoffs associated with the outcomes of different minimum aptitude standards.

RESULTS

Computing the Minimum Satisfactory Performance Score

The sample of Marine infantrymen who took the job performance tests is not representative of the population of potential inductees; the sample of Marine examinees passed the current minimum standards for enlistment in the Marine Corps (AFQT score of 21 for high school graduates) and for assignment to infantry specialties (General Technical (GT) aptitude composite score of 80).¹

1. AFQT scores are on a percentile scale, and GT scores are on a standard score scale with a mean of 100 and a standard deviation of 20.

To correct the sample estimates of the relationship between aptitude scores and job performance so that they approximate the results for the population, the multivariate correction for range restriction was used [3]. The sample data for the JPM infantry examinees are presented in the appendix. The estimated population intercorrelations and standard deviations are also shown in the appendix. The regression equation for predicting performance (P) from GT and TIS is as follows:

$$P = 124 + .66GT + .51TIS,$$

where GT is the General Technical aptitude composite that is used for classification into infantry specialties and TIS is time in service, expressed in months. The standard error of estimate (SEE) for predicting performance is 17.5.

This regression equation was used to compute P for each male in the 1980 youth population. The GT score was available for each person, and TIS was set at a constant value of 24. Because the errors of prediction have been removed from P , the distribution of P cannot be used as is to obtain the minimum satisfactory performance score. Instead, a random component must be introduced into the P scores, and the resulting distribution used to find the 10th percentile.

The random component was obtained by generating a random normal deviate for each male in the population, multiplying this value by the SEE , and adding the product to the P . The distribution of P with the random component is shown in table 1. The P score that corresponds to the 10th percentile is 179.

Note that the above procedure for computing the minimum satisfactory performance score assumes that the residuals are normally distributed, but it makes no assumption about the distribution of P in the population. The linear regression, of course, imposes the distribution of GT on P .

In summary, the population of potential recruits is defined by law such that the bottom 10 percent of the population is not eligible for induction during mobilization. For this analysis, the population of potential recruits is the 1980 male youth population from which the bottom 9 percent of the AFQT distribution has been deleted. Performance scores were computed for this population of potential recruits. From this distribution of predicted performance scores, any score at or below 179 would be unsatisfactory according to the policy decision of a 10-percent failure rate.

Table 1. Distribution of predicted performance scores in the 1980 male youth population.

Predicted performance	Cumulative percent	Predicted performance	Cumulative percent	Predicted performance	Cumulative percent
156	1.0	195	29.7	234	90.3
157	1.0	196	31.2	235	90.8
158	1.0	197	32.9	236	91.7
159	1.1	198	34.4	237	92.5
160	1.2	199	35.8	238	93.3
161	1.4	200	37.3	239	94.0
162	1.6	201	39.3	240	94.5
163	1.7	202	41.2	241	95.1
164	1.9	203	42.8	242	95.6
165	2.1	204	44.1	243	95.9
166	2.4	205	45.7	244	96.2
167	2.7	206	47.3	245	96.6
168	3.0	207	49.3	246	97.1
169	3.3	208	51.2	247	97.5
170	3.6	209	53.0	248	97.9
171	4.1	210	54.6	249	98.0
172	4.7	211	56.1	250	98.3
173	5.3	212	57.9	251	98.7
174	5.9	213	59.6	252	98.7
175	6.5	214	61.7	253	98.9
176	7.1	215	63.4	254	99.2
177	8.0	216	65.5	255	99.2
178	8.7	217	67.5	256	99.3
179	10.1	218	69.6	257	99.3
180	11.1	219	71.4	258	99.4
181	11.9	220	72.6	259	99.5
182	13.0	221	74.3	260	99.6
183	13.9	222	75.9	261	99.6
184	14.6	223	77.3	262	99.7
185	15.7	224	78.7	263	99.7
186	16.8	225	80.3	264	99.7
187	18.2	226	81.6	265	99.8
188	19.0	227	83.5	266	99.8
189	20.5	228	84.2	267	99.8
190	22.2	229	85.1	268	99.8
191	24.0	230	86.2	269	99.8
192	25.4	231	87.5	270	99.9
193	26.8	232	88.2	271	99.9
194	28.0	233	89.1	272	100.0

Computing the Minimum Qualifying Aptitude Score

After determining the minimum satisfactory performance score, the next step is to predict the minimum performance score of 179 from the GT aptitude composite. The computation uses the same regression equation used earlier to determine minimum performance ($P = 124 + .66GT + .51TIS$). The value 179 is substituted for P , and the equation is solved for GT .

Note that the minimum satisfactory performance score is applied at the end of four months TIS vice 24 months TIS. The performance of people at the end of 24 months is the desired level. In practice, however, infantrymen are expected to be satisfactory performers at the end of four months. These two policy decisions--maximum failure rate of 10 percent and unavailability for combat with less than four months TIS--govern the constraints on evaluating minimum qualifying aptitude scores for assigning infantrymen. Because infantrymen are expected to be satisfactory performers at four months TIS, the qualifying aptitude scores should result in predicted performance at the satisfactory level for people with four months TIS.

The GT score that predicts the minimum satisfactory performance score, 179 at four months TIS, is 80. The current qualifying GT score for assigning recruits to Marine infantry specialties is also 80. The close agreement of these two values supports the current practice, which is based on years of experience, dating back to the Vietnam era. Thus, even though manpower managers did not have objective hands-on tests to assess performance or a clearly defined population of inductees, their ability to estimate minimum performance is supported by this analysis.

A sensitivity analysis was conducted to examine the impact on the qualifying aptitude score as a result of changing the rule of thumb used in establishing the performance requirement (the 10-percent rule). By declaring a higher percentage of failures in the population as unacceptable, the operational definition of the performance requirement increases. Based on the JPM regression, higher performance requirements translate into higher qualifying aptitude scores. The converse of each of these conditions is also true.

Table 2 presents the changes in the minimum aptitude score that result from increasing the percentage of the population of unsatisfactory performers. The range for these was from 4 to 16 percent. The corresponding performance score for each percentage of unsatisfactory performers was determined from table 1. The performance-aptitude regression was solved for the aptitude score that would result in the minimum performance score.

While the 10-percent rule resulted in a minimum aptitude standard of 80 (as discussed earlier), the extreme cases of 4 percent and 16 percent netted minimum qualifying scores ranging from 68 to 89. The purpose of table 2 is to assist policy makers as they discuss the implications of a 10-percent unsatisfactory performance requirement and the effects on aptitude standards if this percentage is changed.

Table 2. Impact of changing percentage of population declared unsatisfactory performers.

Unsatisfactory performers (%)	Minimum satisfactory performance score	Qualifying aptitude score
4	171	68
6	174	72
8	177	77
10	179	80
12	181	83
14	183	86
16	185	89

NOTE: Minimum satisfactory performance score is performance at 24 months time in service.

Evaluating Outcomes of Different Aptitude Standards

Although the enlistment standard-setting procedure discussed above is based on objective performance data, policy makers need additional information to confirm its outcome and to determine its impact on the manpower process. The following issues are particularly relevant as policy makers evaluate various aptitude minimums:

- How much larger are failure rates for the inductee population at earlier periods of service compared to the 10-percent failure rate at 24 months?
- What are the failure rates for various accession cohorts--the individuals that were selected into the service based on a given aptitude standard?

- How many potentially successful performers are not eligible to enter the service due to the minimum aptitude standard?
- Will the minimum aptitude standard allow sufficient numbers of recruits to enter the Marine Corps so that manpower staffing goals for the infantry occupational field can be met?

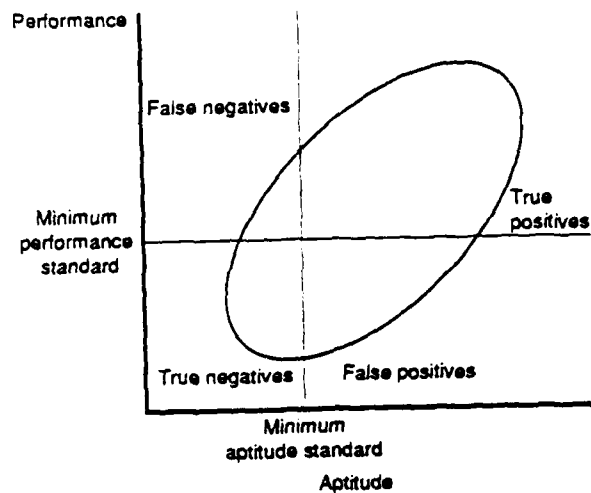
Addressing these issues involves identifying outcomes of personnel decisions that result from various aptitude standards.

Because of the imperfect relationship between aptitude and performance, four outcomes will result from any decisions establishing standards for both the aptitude and performance dimensions. The outcomes for individuals are as follows:

- Above both the aptitude and performance standards--true positives
- Below both the aptitude and performance standards--true negatives
- Above the aptitude standard but below the performance standard--false positives
- Below the aptitude standard but above the performance standard--false negatives.

The four outcomes are illustrated in the figure on the next page. The intent of making personnel decisions is to maximize the percentage of correct decisions (true positives and true negatives) while minimizing the percentage of incorrect decisions (false negatives and false positives). Emphasis must also be placed on the acceptable percentage of false negatives versus the percentage of false positives--reflecting the value of missed opportunities versus the consequences of unsatisfactory performance.

Table 3 shows the percentage of the male inductee population that would occur in each decision outcome for various times in service ranging from 4 through 24 months, and for qualifying aptitude scores ranging from 70 through 90. The table was prepared by generating the predicted performance distributions for the 1980 male youth population, as was discussed earlier, and applying the performance standard of 179 and five-point-interval GT aptitude standards from 70 to 90. These data can help policy makers evaluate the reasonableness of alternative qualifying aptitude standards.



Decision outcomes associated with minimum performance and aptitude standards

The table indicates that the performance standard of 179 resulted in 10 percent failures (unsatisfactory performers) for the inductee population with 24 months TIS. Failure rates for the inductee population are computed as the sum of the percentages for true negatives and false positives--this total equaled 10 percent for all aptitude standards at the 24-month interval.

Performance levels typically improve as a result of a person's experience, so policy makers may also be concerned with the failure rates for the inductee population at earlier times of service. The failure rate for the inductee population increased by two to three points for every four months of service--the 10 percent failures at 24 months was generated from 22 percent failures at four months (table 4). The failure rate for the inductee population is not a function of aptitude, because it is simply the percentage of persons performing below the performance standard of 179 (sum of true negatives and false positives).

Failure rates for accession cohorts do vary as a function of aptitude, because aptitude is one of the primary criteria that determine who enters the service. These failure rates, presented in table 5, reflect the percentage of unsatisfactory performers relative to all who scored above the aptitude prerequisite--the number of false positives divided by the number of true positives plus false positives. The decrement in failure rates for the accession cohort represents the contribution of the aptitude standard in screening out potentially unsuccessful performers. For example, at 24 months TIS, the low aptitude standard of 70 does not reduce the failure rate, while a standard of 90 reduces failures by 4 percentage points (from 10 percent to 6 percent). These examples illustrate the validity of the aptitude composite as a predictor of job performance.

Table 3. Percentage of male inductee population in each decision-outcome category for different time in service and aptitude score intervals

Decision outcome		Time in service (months)	Qualifying aptitude score				
Aptitude	Performance		70	75	80	85	90
Qualified			99	96	93	88	82
	Successful	24	90	88	85	82	77
	(true positives)	20	88	86	84	80	76
		16	86	84	83	79	75
		12	84	82	81	78	74
		8	81	80	79	76	72
		4	79	78	76	73	70
	Unsuccessful	24	10	9	8	6	5
	(false positives)	20	12	10	9	7	6
		16	14	12	11	9	7
		12	16	14	12	10	8
		8	18	16	14	12	10
		4	21	19	17	14	12
Unqualified			1	4	7	12	18
	Would be	24	0	1	5	8	13
	successful	20	0	2	4	8	12
	(false negatives)	16	0	2	3	7	11
		12	0	1	3	6	10
		8	0	1	3	6	10
		4	0	1	3	5	9
	Would be	24	0	1	2	4	5
	unsuccessful	20	0	2	3	5	6
	(true negatives)	16	0	2	3	5	7
		12	0	2	4	6	8
		8	1	2	4	6	8
		4	1	2	4	7	9

NOTE: Some percentages do not equal 100 percent due to rounding.

Table 4. Unsuccessful performers in inductee population, shown by time in service

Time in service	Percent unsuccessful
24	10
20	12
16	14
12	16
8	19
4	22

Raising aptitude standards also reduces the number of persons who are qualified for service (shown in the bottom row of table 5). Note that the percentage of qualified individuals in the inductee population (true positives plus false positives) decreased from 99 percent at a standard of 70 to 82 percent for a standard of 90. While the percentage of unsuccessful performers in an accession cohort decreases (false positives) as aptitude standards are raised (see table 3), this result is at the expense of increasing the percentage of potentially successful performers who do not satisfy the aptitude standard (false negatives).

Table 5. Percentage of unsuccessful performers in accession cohorts,^a shown by aptitude standard and time in service

Time in service	Qualifying aptitude standard					Failure rate for inductee population
	70	75	80	85	90	
24	10	9	8	7	6	10
20	12	11	10	8	7	12
16	14	12	11	10	8	14
12	16	14	13	12	10	16
8	18	17	15	14	12	19
4	21	19	18	16	15	22
Percentage of inductee population qualified on aptitude standard	99	96	93	88	82	

a. Accession cohorts score at or above the qualifying aptitude standard.

Because of the direct relationship between the percentage of false positives and false negatives and the adverse consequences associated with both outcomes, certain tradeoffs must be made. For high aptitude standards, these tradeoffs take the form of economic and social costs of keeping potentially successful people out of the service versus ensuring that a high percentage of the persons above the aptitude standard will be successful. For low standards, the tradeoffs are between larger pools of relatively inexpensive applicants versus large numbers of unsuccessful performers who will require increased training and supervision. The aptitude standard of 80 results in a 5:8 ratio of false negatives to false positives at 24 months TIS (table 6). An aptitude standard of 70 results in a 0:10 ratio; there are virtually no false negatives and 10 percent false positives for a standard of 70 at 24 months TIS. Such a low standard may allow an unacceptable percentage of unsuccessful performers to enter the service. Conversely, a standard of 90 has a ratio of 13:5; 13 percent of those rejected would be potentially successful performers, compared to only 5 percent who would be selected but unsuccessful performers. A standard of 90 may be too restrictive, because it would eliminate a large percentage of capable performers. With no further information concerning the value of either category of incorrect decisions, an aptitude standard of 80 to 85 is the most equitable choice.

Table 6. Ratio of potentially successful performers in inductee population to unsuccessful performers in accession cohort

Time in service (months)	Qualifying aptitude score				
	70	75	80	85	90
24	0:10 ^a 0.0 ^b	2:9 0.2	5:8 0.6	8:6 1.3	13:5 2.6
20	0:12 0.0	2:10 0.2	4:9 0.4	8:7 1.1	12:6 2.0
16	0:14 0.0	2:12 0.2	3:11 0.3	7:9 0.8	11:7 1.6
12	0:16 0.0	1:14 0.1	3:12 0.3	6:10 0.6	10:8 1.3
8	0:18 0.0	1:16 0.1	3:14 0.2	6:12 0.5	10:10 1.0
4	0:21 0.0	1:19 0.1	3:17 0.2	5:14 0.4	9:12 0.8

a. Ratio of false negative percent to false positive percent.

b. Ratio expressed as a proportion.

Table 5 showed the percentage of unsuccessful performers in accession cohorts by various qualifying aptitude standards and TIS. The current and recommended aptitude standard of 80 resulted in a failure rate of 8 percent of the accession cohort at 24 months TIS. This rate reflects the tolerance in the percentage of unsuccessful personnel that the Marine Corps was implicitly willing to allow at 24 months of service. This standard was based on a failure rate of 18 percent at four months, which was also implicitly acceptable. Now that the effects of aptitude standards on failure rates are explicit, adjustments can be made by policy makers. A 5-point change in aptitude results in about a 2-percentage point change in the percentage of failures at four months of service and in about a 1-point change at 24 months of service.

If the Marine Corps would be willing to tolerate 10 percent failures at 24 months TIS, an aptitude standard of less than 70 would suffice. Essentially anyone could be inducted, and at the end of 24 months about 10 percent of this group would be failures. However, a standard of less than 70 results in 21 percent of the accessions having unsatisfactory performance at four months. The costs of such high failure rates in the form of additional training and supervision may be excessive and warrant higher qualifying standards.

As another alternative, if a 10-percent failure rule were applied to the accession cohort at four months of service, an aptitude standard of approximately 100 would be required. (In table 5, the failure rate is 15 percent for an aptitude standard of 90 and four months TIS.) The social costs of such a high standard may be excessive, and a high aptitude standard may place the infantry in undue competition with other occupational fields for high aptitude personnel.

CONCLUSIONS

The current qualifying GT score for assigning recruits to Marine infantry specialties is 80. The method used in this research memorandum for determining the minimum aptitude standard is consistent with previous Marine Corps standard-setting procedures in that objective hands-on performance data were substituted for the training criterion that has historically been used. The close agreement between the current standard and the results of these analyses supports the present standard-setting practices, which are based on experience dating back to the Vietnam era. Even though manpower managers typically do not have objective hands-on tests to assess performance or a clearly defined population of recruits, their ability to estimate minimum performance requirements is supported by these analyses.

Identifying the performance requirement is the most difficult aspect in evaluating enlistment standards. It is also a dominant factor in determining the minimum aptitude score. Specification of the performance requirements must be directly related to the absolute demands of the job. The application of the 10-percent rule has deferred this specification of the absolute job requirements by the Marine Corps. The

assumption is that the 10-percent rule is an accurate assessment of the Marine Corps absolute performance requirements for the infantry occupational field. To the extent that the 10-percent rule is a reasonable estimate of the absolute performance requirements, the minimum aptitude standard of 80 should ensure that significant numbers of unsuccessful performers are not accessed.

The 10-percent rule has been applied with some flexibility in the past, but the general perception has been that higher failure rates result in the unfavorable outcomes of recycles and degraded levels of job performance. The use of the 10-percent rule was one attempt to quantify the performance requirement. Other efforts should be conducted to confirm these outcomes.

In a simple way, the tradeoffs and comparisons among the outcomes of various minimum aptitude standards exemplify the thought processes of policy makers. As with all policy-related issues, extensive value judgments are involved. This paper is a first attempt to make these value judgments explicit by translating decisions into an empirical framework for determining minimum aptitude standards. The tradeoffs have not incorporated explicit costing information. This calculation of a minimum aptitude standard has not been an optimal determination in the sense of balancing the benefits of higher standards (better job performance, fewer failures) against the costs of such standards (higher recruiting costs, and enlistment incentives). However, such tradeoff issues were discussed to highlight the problems confronting policy makers and to serve as an introduction to the issues that must be confronted for the next stage in evaluating enlistment standards--determination of the aptitude distribution above the minimum score.

Significant improvement in selection decisions is the primary reason for using aptitude tests in the accession process. However, because the selection test is not perfectly related to performance, some incorrect selection decisions are inevitable. These incorrect decisions have impacts on the services (who will access a limited number of unsuccessful performers) and on applicants (who would have been successful performers if selected). The goal of setting aptitude standards is to find a balance that would allow the services to accomplish their missions while protecting applicants who seek the advantages that the services have to offer.

REFERENCES

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1. The number in parentheses is a CNA internal control number.

APPENDIX

INTERCORRELATION MATRICES FOR INFANTRYMEN

Table A-1. Correlation matrix for infantry riflemen with up to 24 months time in service (sample values)

	GS	AR	WK	PC	NO	CS	AS	MK	MC	EI	TIS	GT	Job Perf
GS	1.000												
AR	.426	1.000											
WK	.720	.373	1.000										
PC	.499	.344	.523	1.000									
NO	-.125	.154	-.197	-.016	1.000								
CS	.010	.165	-.022	.125	.472	1.000							
AS	.482	.326	.472	-.117	.018	.018	1.000						
MK	.461	.673	.389	.356	.177	.177	.243	1.000					
MC	.561	.520	.500	.390	.128	.128	.502	.372	1.000				
EI	.609	.400	.570	.404	.038	.038	.609	.618	.372	1.000			
TIS	.078	.098	.089	.037	-.008	-.008	.084	.133	.084	.133	1.000		
GT	.686	.792	.709	.577	.139	.139	.652	.878	.133	.652	.133	1.000	
Job Perf	.405	.299	.371	.282	.024	.038	.459	.264	.425	.430	.199	.454	1.000
Std Dev.	7.620	6.653	5.793	6.168	6.204	6.928	8.754	7.343	8.298	8.270	5.475	12.593	20.001

Table A-2. Correlation matrix for infantry riflemen with up to 24 months time in service (population estimates)^a

	GS	AR	WK	PC	NO	CS	AS	MK	MC	EI	TIS	GT	Job Perf
GS	1.000												
AR	.655	1.000											
WK	.768	.627	1.000										
PC	.639	.623	.706	1.000									
NO	.415	.599	.454	.460	1.000								
CS	.404	.521	.424	.436	.640	1.000							
AS	.545	.417	.482	.385	.214	.237	1.000						
MK	.661	.802	.621	.593	.290	.290	.290	1.000					
MC	.639	.623	.558	.506	.342	.357	.671	.536	1.000				
EI	.721	.589	.670	.551	.348	.339	.662	.532	.696	1.000			
TIS	.069	.082	.066	.034	-.013	.020	.114	.060	.124	.079	1.000		
GT	.789	.890	.809	.749	.548	.513	.607	.768	.859	.752	.104	1.000	
Job Perf	.502	.441	.463	.399	.294	.262	.504	.383	.512	.515	.188	.546	1.000
Std dev	8.905	9.315	7.599	8.453	8.637	8.767	8.483	9.815	9.184	8.550	5.468	17.07	21.18

a. Bottom 9 percent of the 1980 Youth Population has been deleted, the population has also been restricted to males only.